An Enemy Within the System: Illustrative Examinations of C2 Questions using Distillations

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ABSTRACT

The events of 11 September have motivated a great deal of research within the United States Marine Corps Combat Development Command modeling effort called Project Albert. The beginnings of one such effort will be described in this paper. Distillation models are used by a collaborative team of researchers from the United States and Sweden to begin to examine questions related to homeland defense. Two basic types of illustrative scenarios are examined in this paper. In the first the enemy blends within a general population, while in the second the enemy is actually embedded in the force. The paper describes the results of base case scenarios and excursions with different C2 measures of effectiveness using the NATO Code of Best Practice for C2 Assessment as a guide. The distillation models ISAAC and Socrates were run many times within the process of Data Farming to support the risk and sensitivity analyses described in the Code. Excursions examined in the research include changes in the nature and number of enemies, commander trust, communication intervals, and communication ranges. Results presented are preliminary, however, the robustness of various C2 structures across these changes in the system is the intended focus as this research continues.

Key Words*: Data Farming, Distillation Models, Homeland Defense.*

1.0 INTRODUCTION

The United States Marine Corps Combat Development Command Project Albert seeks to advance the state of the art in modeling, simulation, and analysis of questions important to the United States Marine Corps and collaborators around the world. These questions are relevant to C2 doctrine, force structure, tactics, techniques, and procedures for the asymmetric environments, the process involved in course of action development, and many other important areas. In the area of C2, collaborative arrangements between Project Albert and researchers in Sweden are emerging because of shared interests and synergistic capabilities residing in the defense establishments of the two countries.

Project Albert exploits advances in high performance computing power, data perception techniques, and new and existing methods of simulation and decision support. It attempts to capture three important phenomena in the context of combat modeling: nonlinearity, intangibles, and co-evolving decision landscapes. Project Albert

Paper presented at the RTO SAS Symposium on "Analysis of the Military Effectiveness of Future C2 Concepts and Systems", held at NC3A, The Hague, The Netherlands, 23-25 April 2002, and published in RTO-MP-117.

Report Documentation Page

Form Approved
OMB No. 0704-0188

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

1. REPORT DATE **00 DEC 2003**	2. REPORT TYPE **N/A**	3. DATES COVERED **-**
4. TITLE AND SUBTITLE **An Enemy Within the System: Illustrative Examinations of C2 Questions using Distillations**		5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **The MITRE Corporation 3300 Russell Road Quantico, VA 22134 USA**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR’S ACRONYM(S) 11. SPONSOR/MONITOR’S REPORT NUMBER(S)
12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release, distribution unlimited**		
13. SUPPLEMENTARY NOTES **See also ADM001657., The original document contains color images.**		
14. ABSTRACT		
15. SUBJECT TERMS		

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**UU**	**29**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

distillations (fast, easy to run models which distill the essence of a particular question) may provide hope in modeling and analyzing non-conventional threats. These distillations are used in conjunction with the Data Farming methodology to explore possibility spaces using many, often millions of, runs. This large volume of data along with the ability to sift through it quickly and efficiently and grow more data in areas of interest is a fundamental idea being pursued within Project Albert that may help answer the questions at hand. Combined with current methods, this process may produce insights not achievable with the current system of combat models and analysis tools alone.

In this particular paper, we describe the use of Project Albert ideas within the philosophy of modeling C2 described in the NATO Code of Best Practice for C2 Assessment in a beginning look at two different meanings of "an enemy within." One is an enemy within the population and the second is an enemy within the force itself. In this first case, having an enemy in the midst of a population and not easily recognizable is an age old phenomena that was starkly brought to the forefront on 11 September. Secondly, the phenomena of having insiders or traitors has been discussed since the age of Sun Tzu. But in the scientific field of command and control today we are still lacking a deep understanding of the nature of an enemy within the system. It is reasonable to assume that an enemy within the system will degrade the system effectiveness, and by better understanding the nature of this situation we hope to begin to develop a deeper understanding of the consequences of having enemies within the organization.

2.0 EXAMINING C2 QUESTIONS USING THE NATO CODE OF BEST PRACTICE

At the outset we would like to state three points about our C2 research. First, we would like to stress that this paper describes research that is just beginning and as such the "results" are not findings so much as guidance for future research on C2 questions. Thus the reader will see that the research is characterized as "illustrative" throughout the paper. Second, it should be noted that the data farming of distillations emphasized in this paper is not meant to give the final answers to C2 questions, but to be part of an overall process called Operational Synthesis. This process (described in more detail in Maneuver Warfare Science 2001) uses models and simulations at different levels of verisimilitude and various methods of operations research to attempt to get at the answers to questions. Third, as both a nascent and multinational research project, the application of the NATO Code of Best Practice (CoBP) for C2 Assessment is particularly appropriate for this research.

The guidance contained in the NATO CoBP is intended to assist research teams, especially as research is beginning. Particularly germane to this research is the emphasis on iterations through the assessment and we consider this research to be just the first iteration used to scope the questions at hand. Also, the questions and methods are structured so as to encourage creativity and lateral thinking as recommended by the CoBP. Finally distillations and the methodology of Data Farming are used. Because distillations are fast running models they allow for many runs and an exploration of a large landscape of possibilities. And data farming allows for the iterative exploration of areas of interest that the researcher thinks may shed light on the questions at hand. Together distillations and the data farming of distillations allow for the scoping of the space of possibilities as encouraged by the CoBP as well as a guide to more focused C2 assessments as recommended in the CoBP.

The C2 questions at hand include the effects of the number, density, and range of sensors out to identify the enemy within, as well as the range that information received can be communicated. Another question area involves information assurance with an examination of the effect of different "trust" levels, i.e. how much the force believes the information communicated. The effect of a "false alarm," or an agent that is incorrectly

identified as one with the intention of committing a terrorist act is also examined. Questions related specifically to an enemy within the force itself were examined by varying the competence level of one of the agents. Research in this area at this stage is quite limited and the intent is to extend it to different levels of command, different numbers of enemies, and different characterizations of the enemy within. Of course, the interaction effects of all of these factors and others with C2 capabilities is something that will be explored as the research continues using Data Farming with distillations within the CoBP philosophy.

3.0 ENEMY WITHIN THE POPULATION

The first case of an enemy within that we will examine is when the enemy is blending into the general population in some way in order to eventually do harm against a target of high value located within the homeland of the general population. Obviously the World Trade Towers and the Pentagon qualify as high value targets of this kind and the attacks on these places motivate this research. Our objective in this paper, however, is not to model the events of 11 September specifically or of any particular real world event that has occurred. Our focus in this research is to examine questions related to C2 in a generic homeland defense context to develop a deeper understanding of what it means to have an enemy within the system, help guide further research in this area, and eventually perhaps help decision makers make choices resulting in more effective homeland defense.

We begin by examining a single enemy that tries to avoid detection and reach a high value target. Specific questions related to C2 are: What is the effect of different levels of agents in the general population with the ability to detect the enemy?, What is the effect of a second red agent as a distraction on detection of the first?, and What are the effects of sensor range, communication range, and information assurance on blue force ability to stop red from reaching the high value target? We use Data Farming and the distillation model ISAAC to investigate these questions across a variety of changes in both the characteristics of the enemy as well as the blue side, but as research continues, we hope to gain a better understanding of the effectiveness of the blue force in stopping an enemy within the system across a wider landscape of possibilities.

3.1 ISAAC

ISAAC is an agent-based simulation modeling system where the input scenarios can be created and altered quite quickly using a text editor. The underlying methodology driving the distillation is a hard-coded physics-based approach. ISAAC represents agents via three states: alive, injured, and dead. Agent behaviors are determined by personality traits that include propensity to move toward or away from other agents or goals; by intangible factors such as unit cohesion, trust, and aggression; and by physical characteristics which determine the agent's weapon capability, sensor range, and communications range. ISAAC can maintain up to three levels of command and control: a global commander, a local commander, and an individual agent/squad. Up to ten squads can be defined, for which different variable personality and physical parameters can be assigned. Terrain is represented as obstacle blocks which impede movement and shot capabilities, but not line of sight. For a more complete description the reader can refer to Maneuver Warfare Science 1998.

3.2 Illustrative Scenarios

Two closely related ISAAC scenarios were developed for this study. Both scenarios include three major entities: a centralized protective force (blue), a dispersed "civilian" population (also blue), and a single enemy agent (red) that represents a terrorist with the mission of reaching (and thus, in our minds, destroying) a high value target. The second scenario also includes a second red agent that does not go for the target thus

representing potential "false alarms." As in all of the work presented in this paper, the reader must remember the illustrative nature of the scenarios, i.e. they are simply dots and results should not be considered in isolation. We are motivated by our desire to understand the effect of civilian sensivity to suspicious or threatening behavior on the ability to stop the enemy. Thus in this work we create notional representations to try to capture the essence of a situation in order to try to add insight to pertinent questions. That being said, in the base scenario the "terrorist agent" is initially positioned randomly in the lower quadrant of the field. This agent seeks to avoid the population and the protective force and attempts to reach the high value target represented by the blue flag. The blue population is distributed evenly over the playing field and the individual agents maintain a random walk around their initial positions. Neither the population or the red agent are given any weaponry. The protective force will pursue the red agent if they are aware of its position and they have weaponry and will stop the red agent if they are within firing range. If a population agent senses the red agent it may communicate the position of the agent to the protective force if the population agent is within communication range. If the red agent succeeds in reaching the goal, it is considered a blue loss while if the agent is killed, it is considered a blue win.

In these scenarios the blue population's sensor range represents the level to which the population has the ability to observe and identify possible terrorist activity. The number and density of the blue population represent the number or portion of the population able to observe and identify. The blue flag (marked as a blue "+" in Figure 1) represents the set of possible high value targets that the red agent may attack. Communication range represents the ability of the protective force to receive terrorist sightings from the population and the communication weight represents the "trust" the force places in these sightings. For this study, several of these parameters were varied to examine the effects communication, training, and trust have on the ability of the blue force to ward off a terrorist attack.

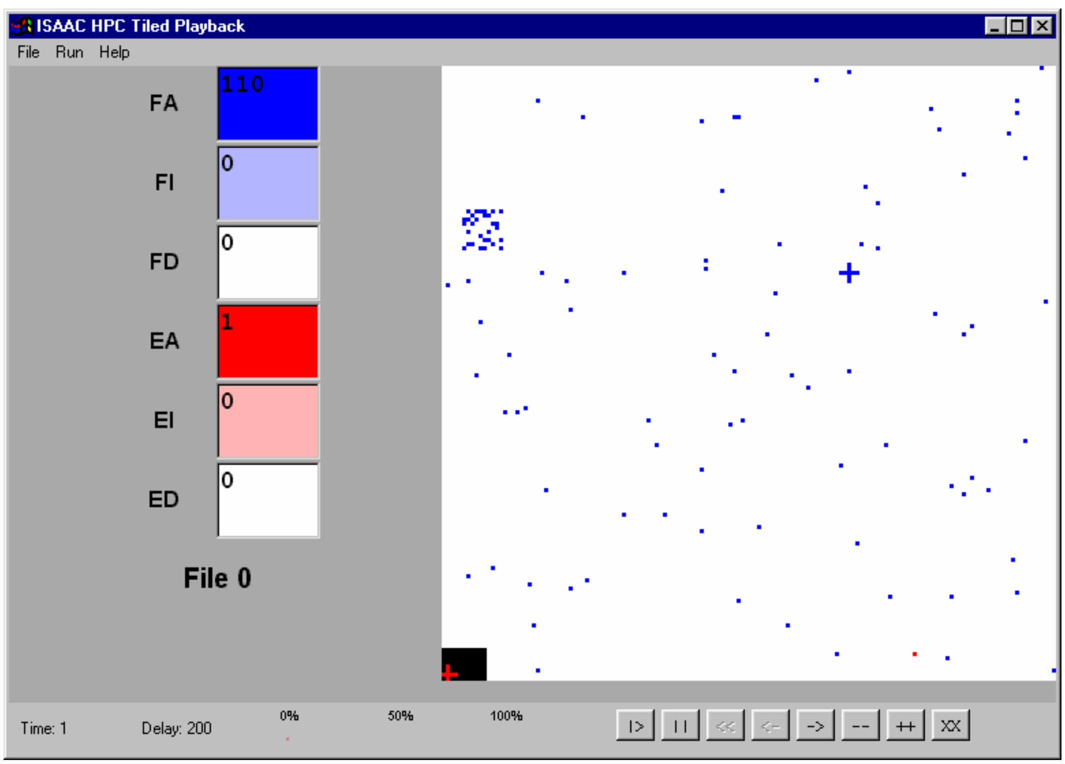

Figure 1: ISAAC Scenario 1 – Single Red Terrorist.

The second scenario (shown in Figure 2) includes a distracting agent or "false alarm." This red agent does not move toward the goal but maintains a random walk which can wander into the sensor range of members of the population. This entity can serve to distract the protective force from the agent who is attacking the goal. The sightings and reporting of this agent can represent either purposeful misinformation or occasional blunders on the part of the population.

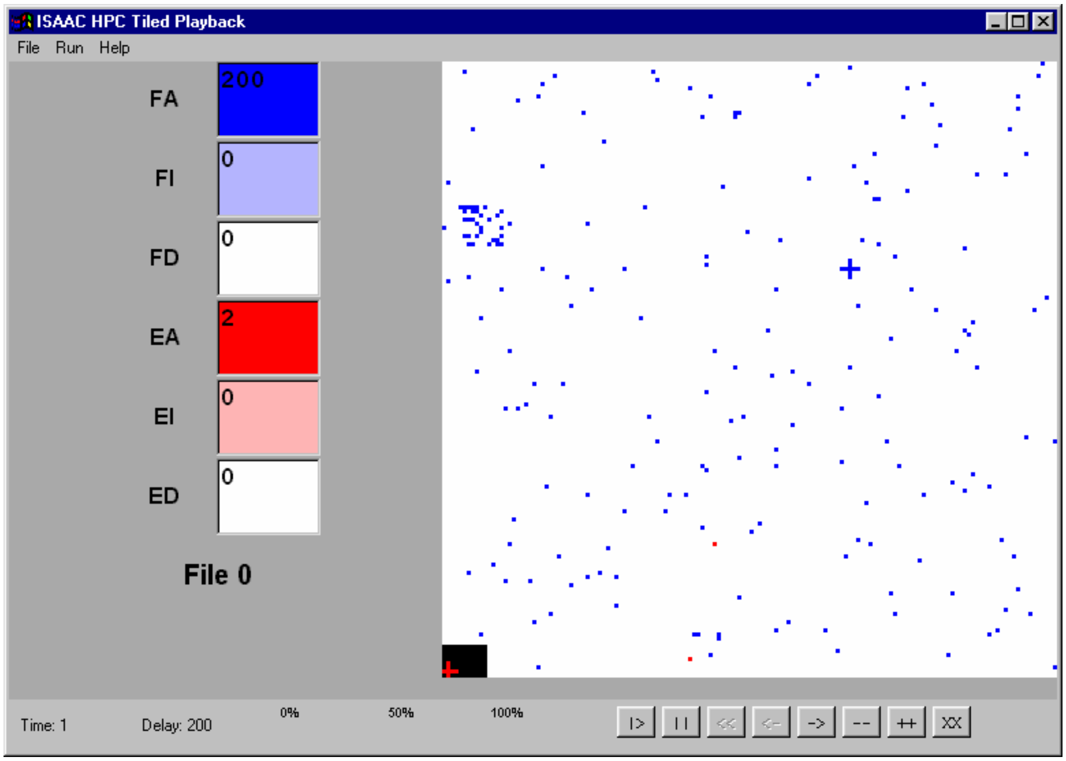

Figure 2: ISAAC Scenario 2 – False Alarm.

3.3 Illustrative Results

A total of more than 300,000 runs of these ISAAC scenarios were executed at the Maui High Performance Computing Center in order to examine the effect of parameter variations on the illustrative scenarios. The following figures present these results as "landscape" plots. The X and Y axis of these plots represent variations in the input parameters of the scenarios. Every combination of input parameter variations was executed 30 times in order to allow examination of the possible statistical variation of the scenario.

Figure 3 shows the effect of an increasing density of "trained" observers within the general population. In this scenario, which has a single red "terrorist" agent, the number of population agents was increased from 40 to 80 and then to 120. The X axis in the plots represents blue sensor range. The Y axis represents blue communication weight. The Z axis represents the "terrorist" agent's effectiveness in reaching the target. Note that as the density of observers increases, the red agent's success rate, in general, goes down.

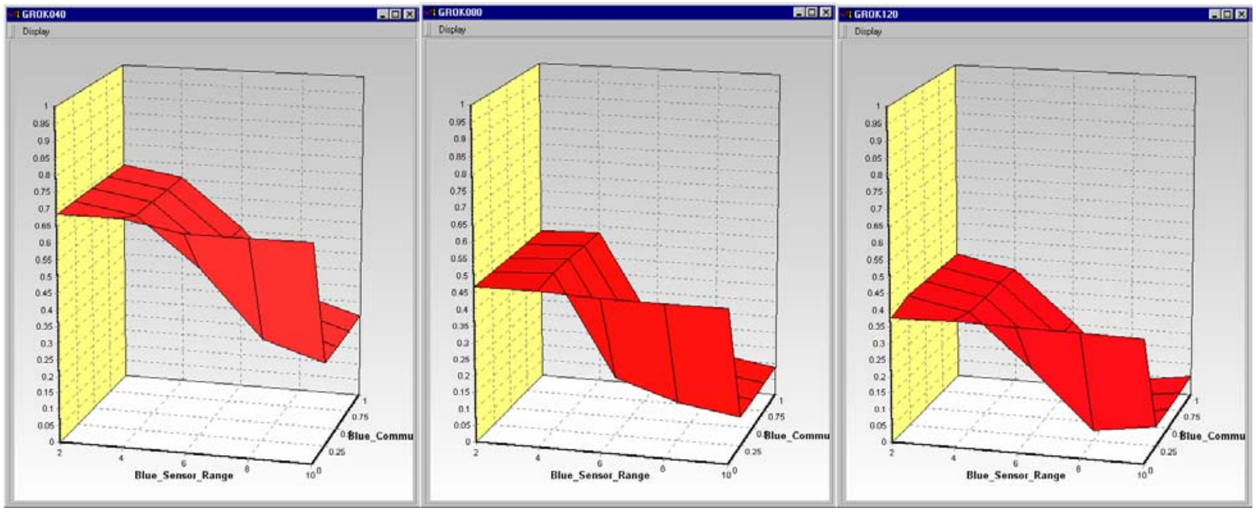

Figure 3: ISAAC Scenario 1 – Population Density Variation.

Figure 4 shows that the "False Alarm" agent has a significant effect on blue ability to ward off the attack on the high value target. In the figure, the vertical axis again represents red effectiveness at reaching the high value target. The top landscapes represent the maximum and the lower landsapes the mean of 30 replications of ISAAC for the given scenario and parameter set. Similarly, Figure 5 shows the more modest impact that increasing the blue population's sensor range has on blue's effectiveness and Figure 6 demonstrates that the communication weight has almost no effect on the red's ability to reach the high value target.

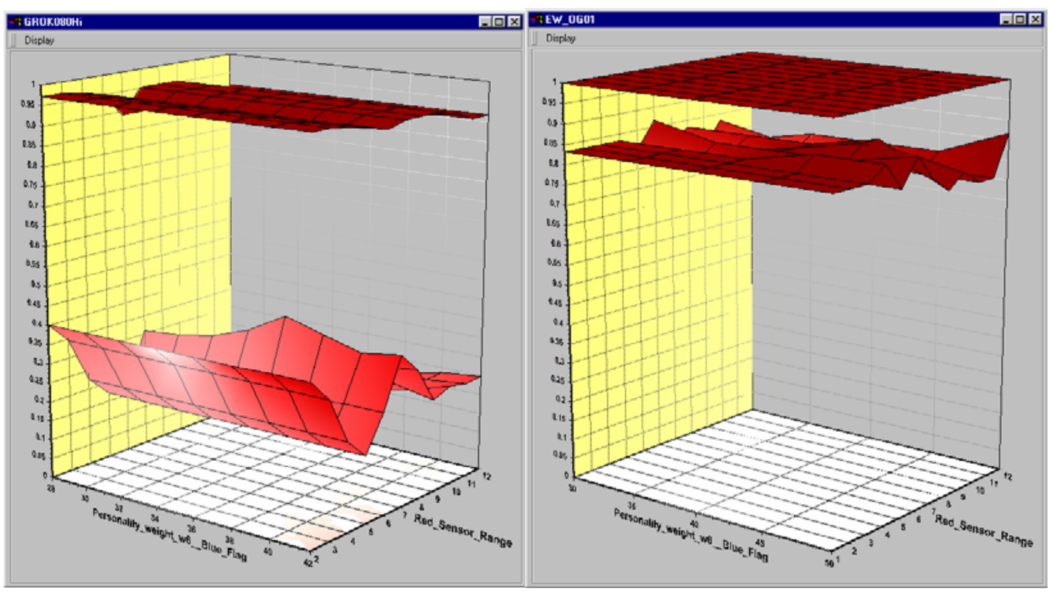

Figure 4: ISAAC Scenario 1 and 2 – Blue Sensor Range = 6.

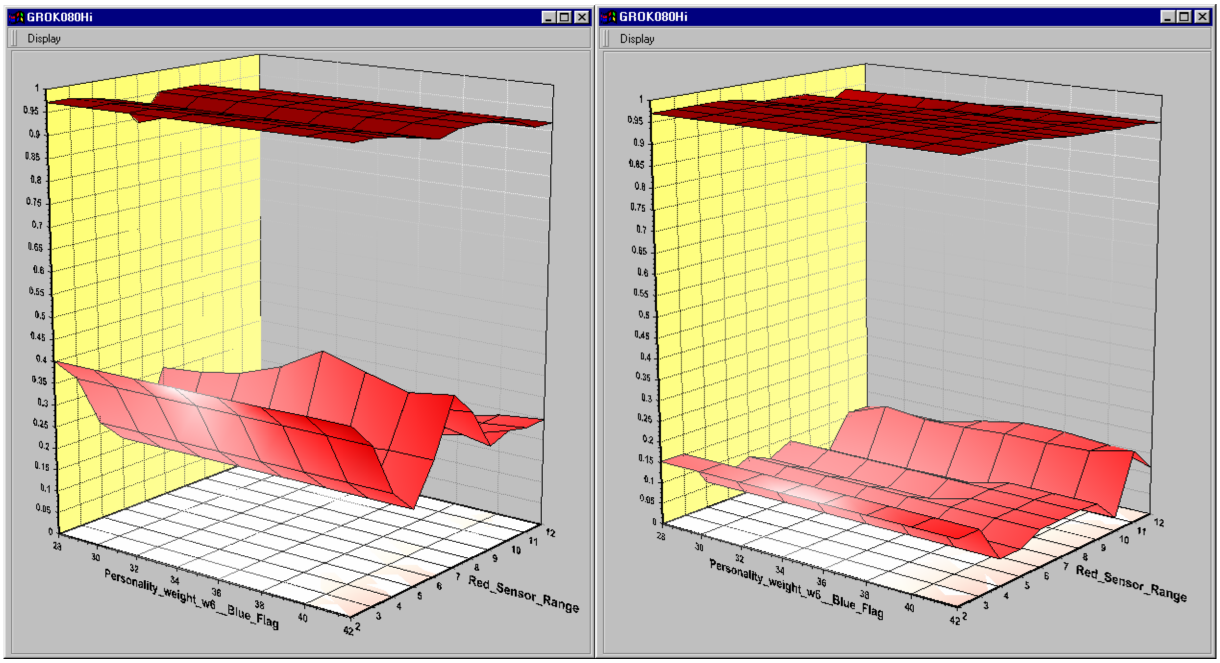

Figure 5: ISAAC Scenario 1 – Blue Sensor Range = 6 vs. 10.

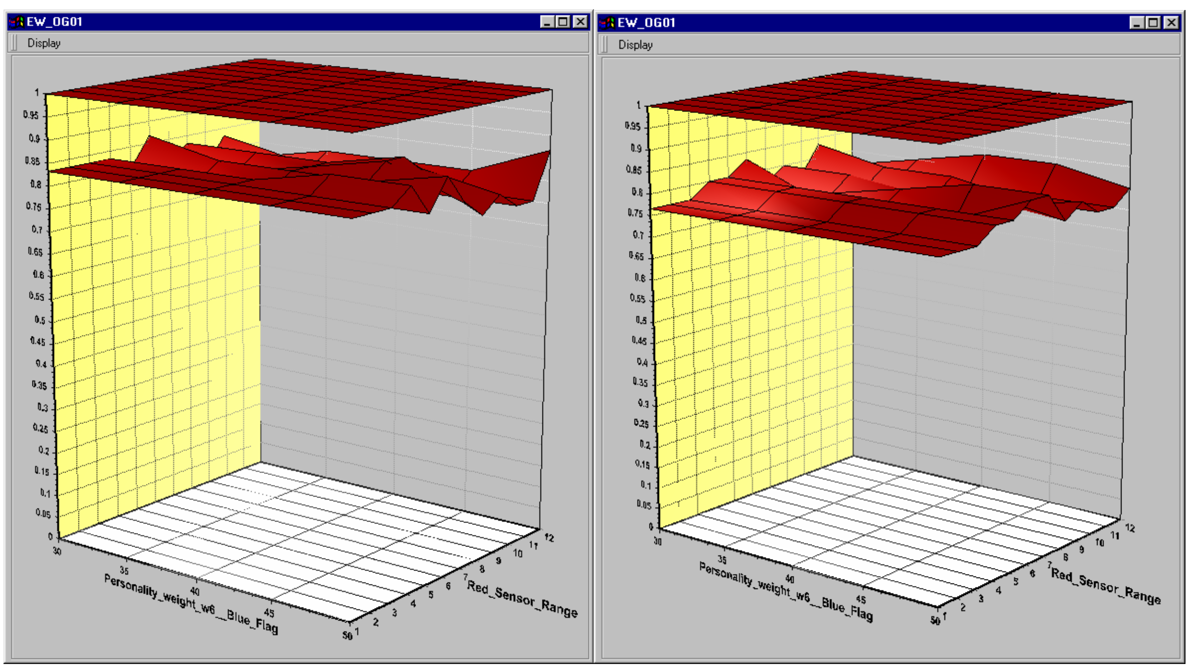

Figure 6: ISAAC Scenario 2 – Blue Communication Weight = 1.4 vs. 0.1.

4.0 ENEMY WITHIN THE FORCE

One of the worst situations a military commander could face is to have an enemy within the force. To have an enemy within a group of trusted ones creates an extremely stressful situation. The fact that this enemy is not visible creates situations where traditional ways of conducting war are not suitable. Through history the literature describes stories about spies and insiders that by their position within an organization could create major damage and chaotic situations, both physically and psychologically. All the way back to the days of Sun Tzu days the common opinion is that having an "agent" placed inside the opposite force creates advantages that potentially gives success for one side and a major disaster for the other.

But today we lack a deep understanding of what it means to have an enemy within the system. Our focus of effort in this research is to explore further the nature of insiders and their role on a system's ability to achieve results, or in other words the degradation of system effectiveness that these insiders may cause. Using Data Farming and the distillation model Socrates we began a series of illustrative examinations in order to investigate the impact of insiders on system effectiveness. We designed a number of different excursions in order to investigate the insider's nature and role. The enemy within the force in this initial work takes the form of degradation of capability, i.e. incompetence. What we examined in this initial work is limited, but illustrative. Further work will include (1) the impact of the number of insiders, (2) the impact of insiders placed within different levels of the organization, and (3) the impact of various levels of robustness of the insiders. In general, as this research continues we will search for a better understanding of *what it means to have an enemy within the system.*

4.1 Socrates

Like ISAAC, Socrates is an agent-based distillation modeling system. Socrates scenarios are developed using an XML editor. Socrates uses a values-driven methodology as its approach. Agents within Socrates are represented as either alive or dead (injured states do not exist in this distillation). There are three levels of command in Socrates. They are the top level commander, middle level leader, and an individual often referred to as a "grunt." Agents can be defined individually and any given number of agents instantiated. Tactical decisions are determined by the agent's position in the command and control structure; by intangible factors such as trust and allegiance; as well as physical characteristics such as weapon capability, sensor range, and communication channels and ranges. Terrain is represented as obstacle blocks which impede movement, however, neither line of sight nor shot capabilities are degraded. More information can be found on the Military Science and the Project Albert websites listed in the references.

4.2 Illustrative Scenarios

Socrates scenarios were developed to examine the effects of the enemy within the system, in this case manifested as incompetence within a hierarchical command and control network. The scenarios were designed to include a single main commander, three secondary commanders, and nine grunts. Two screen shots demonstrating the scenario are included as Figure 7. The initial layout of the scenario is the same in the base case as well as subsequent excursions. The base case is a standard force on force, evenly matched battle of blue against red. There is no high value target, per se, but territory control is the de facto "high value target." Experimental data farming runs were setup to explore the effect "incompetent" grunts have on the outcome by varying the weapon and the sensor of one or more combatants on a single side. Data was collected in three cases: 1) the base case with evenly matched forces, 2) an excursion with one "incompetent" blue grunt; and 3) an excursion with one "incompetent" blue grunt having variable levels of "incompetence."

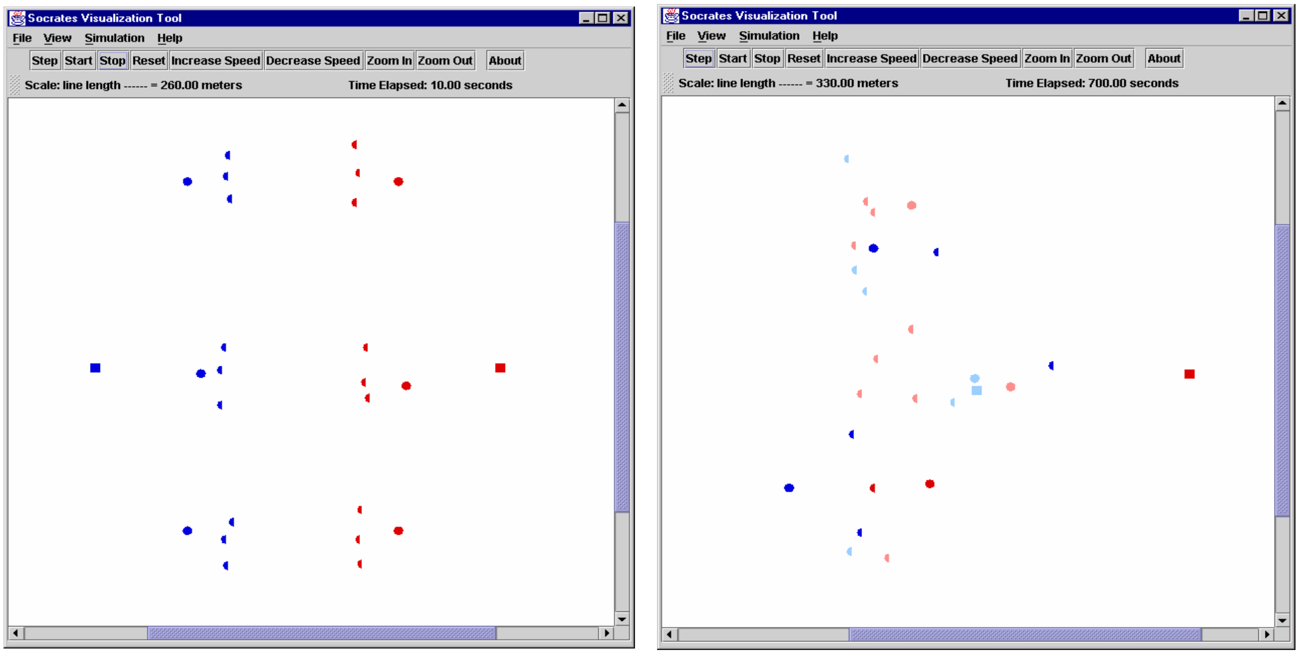

Figure 7: Socrates Scenario at Two Different Time Steps.

4.3 Illustrative Results

For each case, a total of 30 replications per parameter combination were executed at the Maui High Performance Computing Center. In the base case, all blue agents have the same weapon capabilities and sensor range. Red agents also have the same parameter settings as blue, the main difference being tactics. The parameter space under study included the following variations: blue weapon probability of kill (pK) ranged from .001 to .009 by increments of .002, blue weapon range varied from 300 to 700 by increments of 100, and blue weapon radius ranged from 1 to 4, by increments of 1. In the case of an "incompetent" grunt, a single bad blue grunt was inserted into the middle of a tactical formation. This "incompetent grunt" has weapons range of 10.0; weapon radius of 2; and pK of .001. Competent blue grunts have a weapon range of 500, a weapon radius of 2, and a pK of .005. All other blue parameters are the same as in the base case. Red agents also have the same parameter settings as the base blue agents, the main difference, again, being tactics.

Figure 8 represents the data for the base and the "incompetent" case where sensor range is the variable parameter. The plot on the left demonstrates the base case and the plot on the right demonstrates the "incompetent" case. The three landscapes in each plot from top to bottom represent maximum, mean, and minimum red kills over 30 replicates. The data presented in this figure indicate that, as pK settings increase, regardless of weapon range and sensor range, blue's ability to kill red agents increases on the average. Although the shape of the landscapes for the two cases is slightly different, the means for this particular set of parameter combinations are similar. The same trend is present across all sensor range variations.

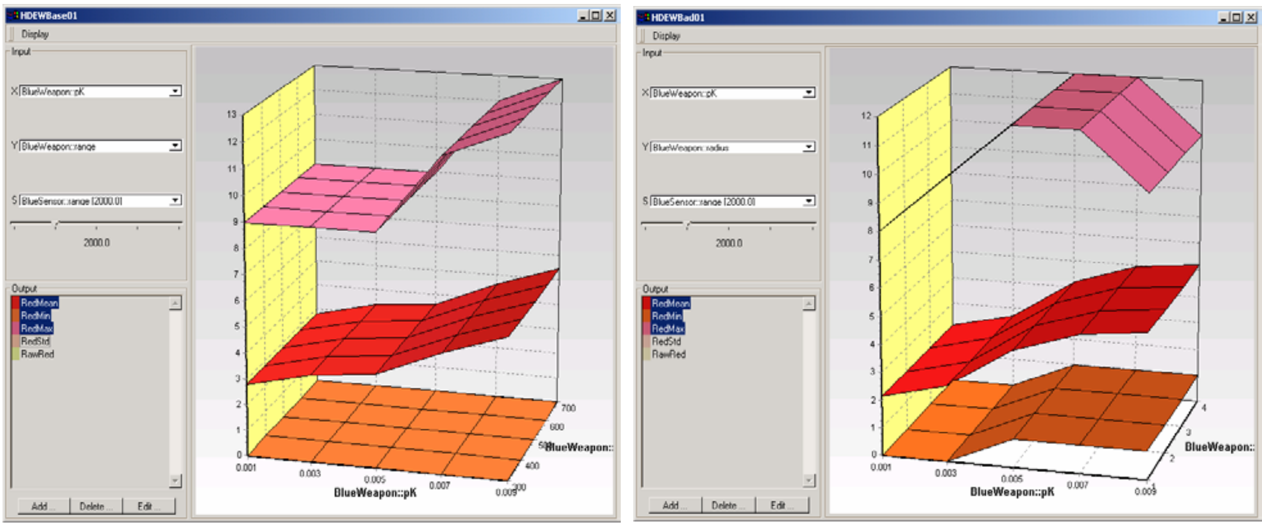

Figure 8: Competent vs Incompetent Case – Variable Sensor Range.

Figure 9 represents the same scenario depicted in Figure 8, only weapon radius is the variable parameter. The outcomes for this combination of settings highlight a different result than Figure 8. As pK settings increase to .005, regardless of weapon range, blue's ability to kill red agents on the average increases, similar to the base case. However, when pK reaches .005, weapon range reaches 500, and weapon radius is 3, average red kills for the "incompetent" case dramatically drop until weapon range increases to 700. The base case results remain consistent with Figure 8. The decrease in red kills for the "incompetent" case could be due to the distance between the incompetent grunt and the two competent grunts on its flanks. One plausible explanation for this dynamic is the relationship between the fields of fire and the "physical" distance between the grunts. When the radius and the range of the weapons is small there is little or no overlap between the grunts' fields of fire. When this occurs, the incompetent grunt receives no help from the flanking competent grunts. As weapon radius and range increase, the overlap among fields of fire increases, allowing the incompetent grunt to receive help from the flanking competent grunts.

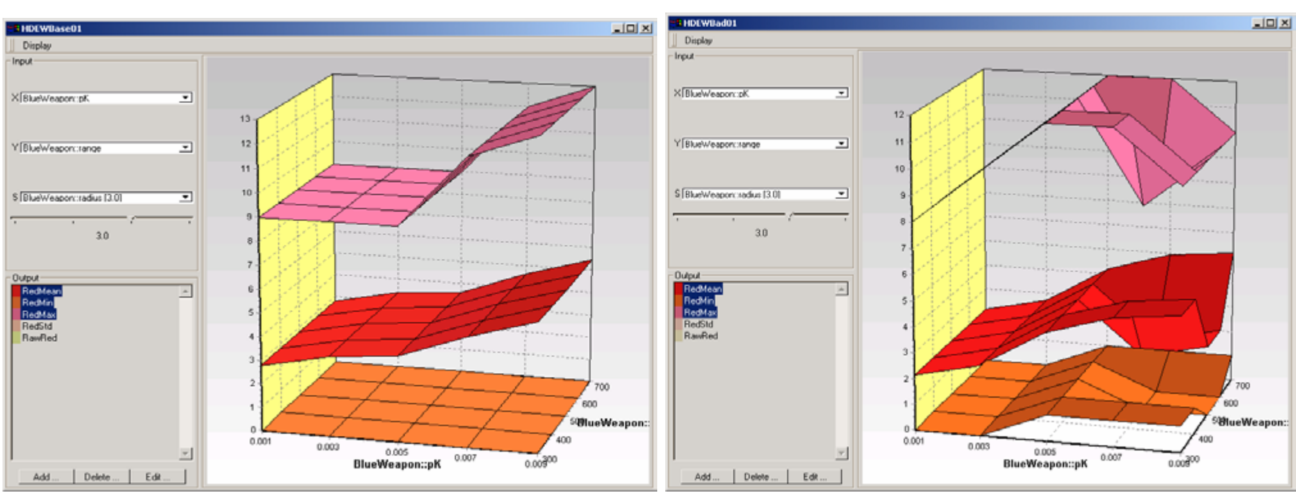

Figure 9: Competent vs Incompetent Case – Variable Weapon Radius.

Figure 10 displays diagrams of this potential phenomenon. In the first diagram, weapon range and radius are small enough that overlap does not exist, but the blue and red agents are not within firing range of each other. Therefore the fact that one blue grunt is incompetent does not impact the situation. In the last diagram, weapon range and radius are large enough that overlap exists between the competent grunts to compensate for the incompetent grunt's low weapon capability. In the middle diagram, overlap is nonexistent and the incompetent grunt impacts the outcome since the gap between the competent grunts is larger than their weapons capability.

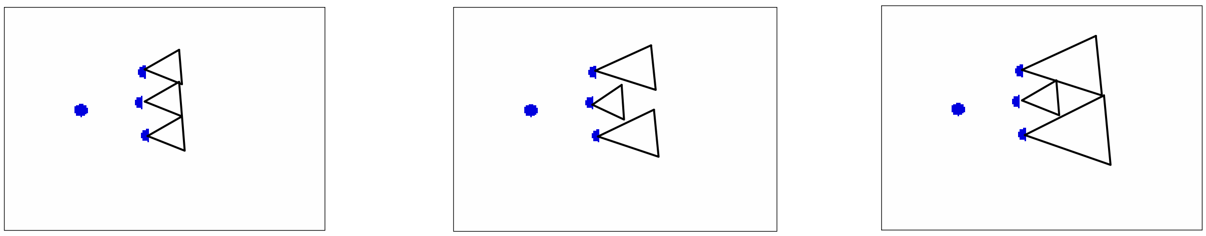

Figure 10: Weapon Fields of Fire Diagram for Competent and Incompetent Grunts.

Figure 11 depicts the third excursion in which the level of one blue grunt's competence is varied to an extreme, from incompetent to extremely incompetent. The figure depicts the fact that the model showed differences in incompetence had little effect. But interestingly, there was a slight negative effect when the incompetent grunt's weapon range was approximately equal to the distance between the incompetent grunt and the competent grunts on its flanks. This appears to be consistent with the results obtained from earlier runs (the fields of fire data) noted in Figure 9.

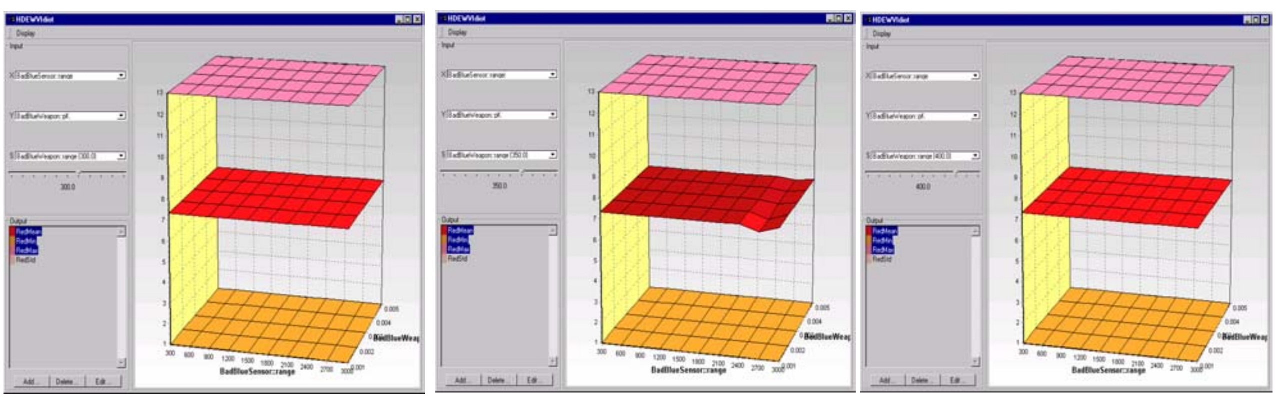

Figure 11: Extremely Incompetent Case – Variable Weapon Range.

5.0 SUMMARY AND FUTURE RESEARCH

In summary, our work is illustrative in nature, but questions regarding C2 in homeland defense scenarios are critically germane at this time. The use of distillations and Data Farming within the philosophy of modeling described in the NATO Code of Best Practice for C2 Assessment may be one way of gaining a better understanding of the answers to these questions. The research described in this paper is a beginning look at

two different meanings of an enemy within the system, but plans are for future research along three distinct threads as researchers from the US and Sweden continue to collaborate.

One thread is to flesh out the research started with the given scenarios. Additional ideas include modeling the enemy within the population scenario in Socrates and the enemy within the force scenario in ISAAC, varying the number of both active and distracting red agents, varying the position and number of blue agents, and varying the weapon radius at the same time introducing the possibility of fratricide. Of course, sorting through the resulting "mountain" of data will be formidable, but tools being developed within Project Albert should be useful in this regard. A second thread is to take situations where the research engenders a "flash" of insight within personnel with military and/or homeland defense experience and iteratively produce more data in the areas of interest or potential insight. Workshops within Project Albert have shown that the process of attacking questions with distillations within multi-disciplinary groups often produces emerging ideas and initially counterintuitive results that can be pursued fruitfully and rapidly with distillations and Data Farming. A third thread is to create new scenarios that will allow us to look at the enemy within at different levels of command and control. This research would include plans to examine an enemy who, because of some triggering event, suddenly goes from dormant to "hot" in a given situation. New models, such as MANA and Pythagoras, being added to the suite of models available within Project Albert for Data Farming on high performance computing platforms as well as planned additional feature in Socrates should allow for this examination in the near future.

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www.militaryscience.org/distillation

www.projectalbert.org

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The authors would like to acknowledge and express their appreciation to ***Sarah Johnson, Matt Koehler, Mary McDonald,*** *and* ***Ted Meyer*** *for their contributions to this research.*

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Presented at the NATO Symposium
Analysis of the Military Effectiveness of Future C2 Concepts and Systems
23-25 April 2002
Den Haag, The Netherlands

Collaborative Research

- United States Marine Corps Project Albert
- Swedish National Defence College
- Question-based using Data Farming of Distillations

Context: Homeland Defense

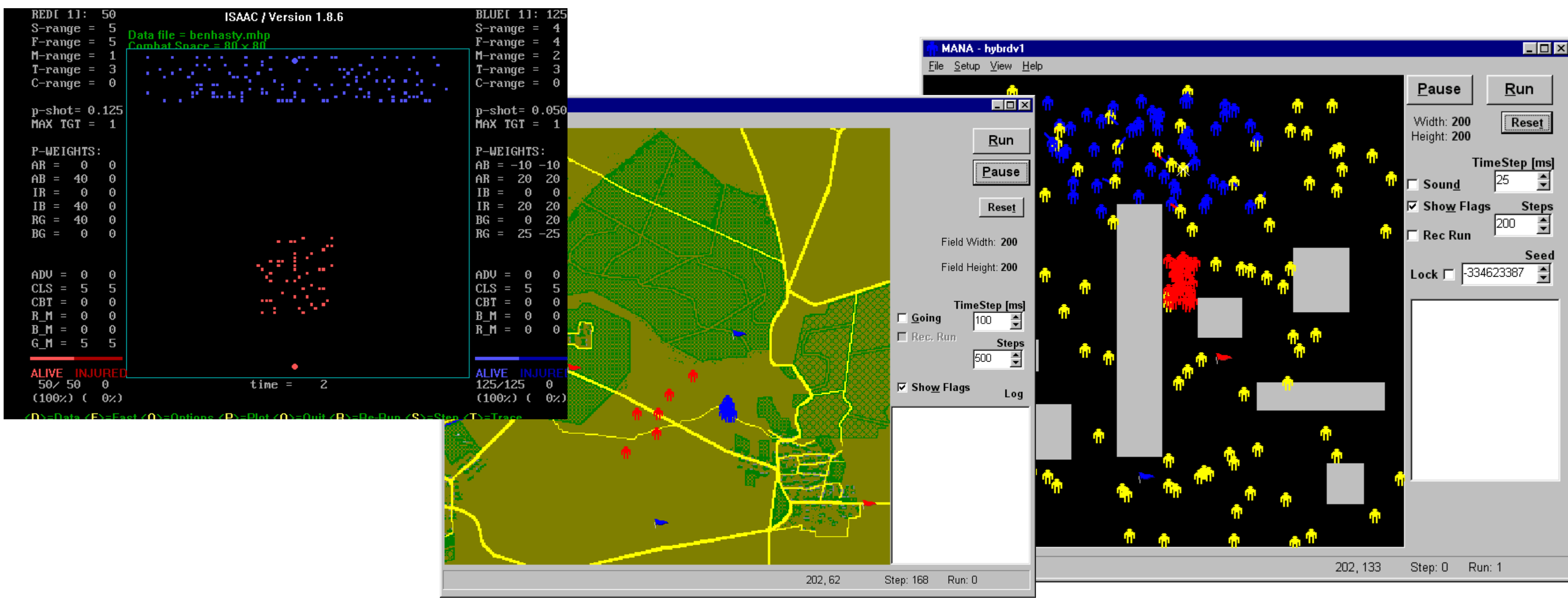
- **Enemy within the Population**
- **Enemy within the Force**

Guidance: NATO Code of Best Practice for C2 Assessment

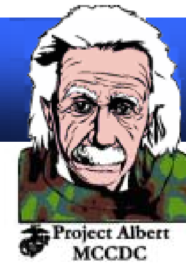
- Innovative modeling tools
- Scoping the space of possibilities
- Iterative approach to C2 questions

Distillations

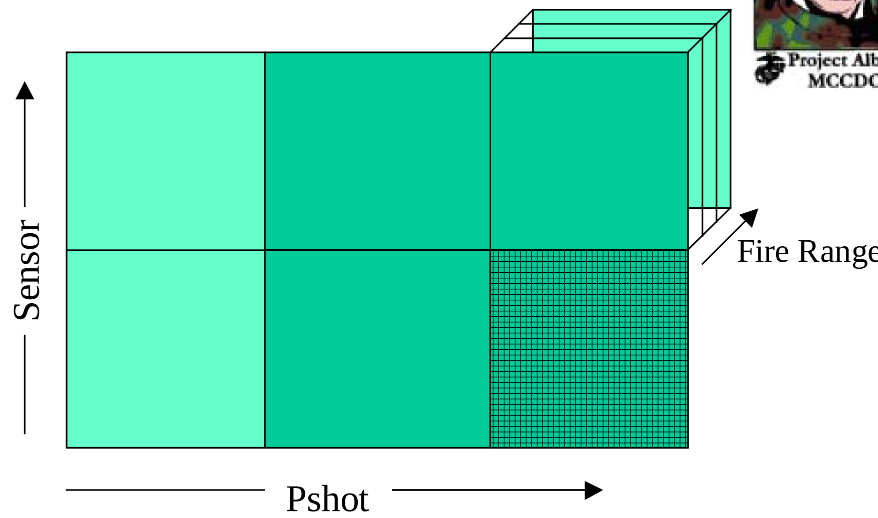
- **Distillation Models** – Agent-based model that is intuitive, transparent, transportable, and farmable.
- Agents – autonomous, reactive, motivated, adaptive, sociable, mobile, proactive, and they communicate.
- **In other words, a bottom up distillation of the essence of a question**



Data Farming



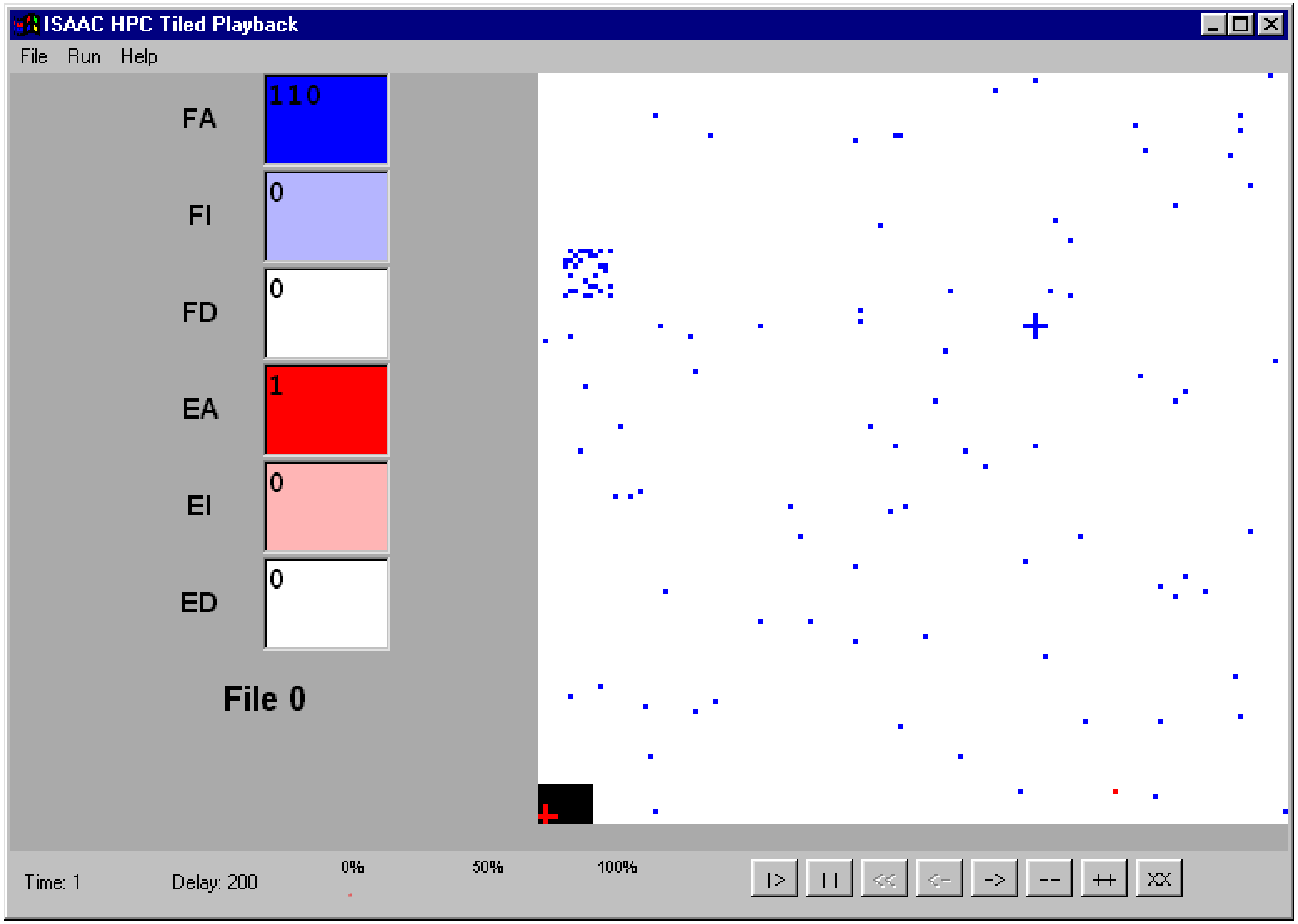
- Execute distillation varying initial conditions and parameters.
- Explore resultant data space using visualization/analysis tools
- Grow data by expanding or increasing the resolution of initial conditions and parameters. Grow Data by:



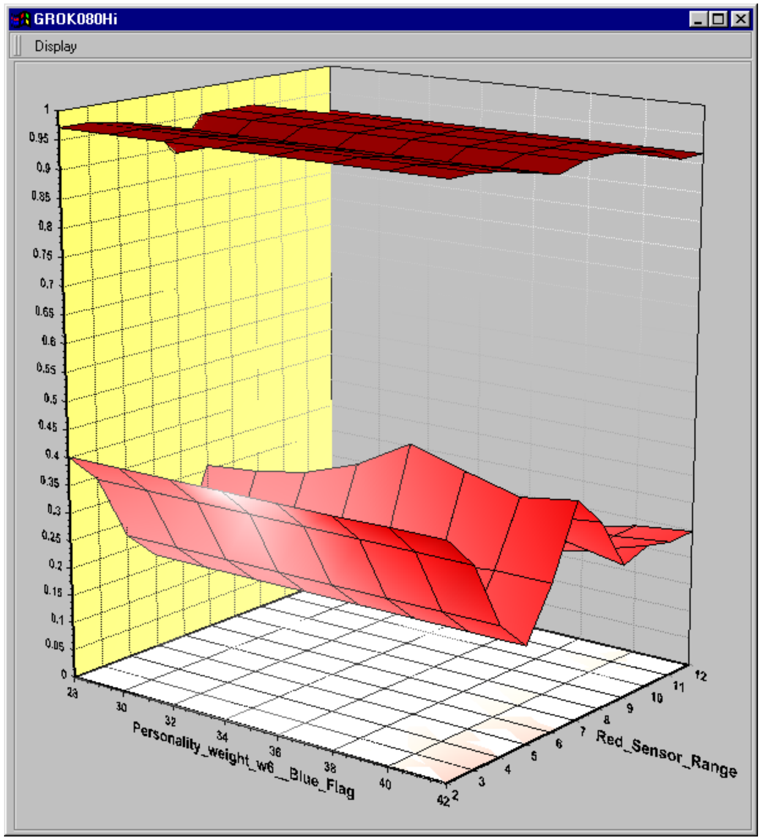
Adding dimensions Increasing fidelity Expanding bounds Increasing trials

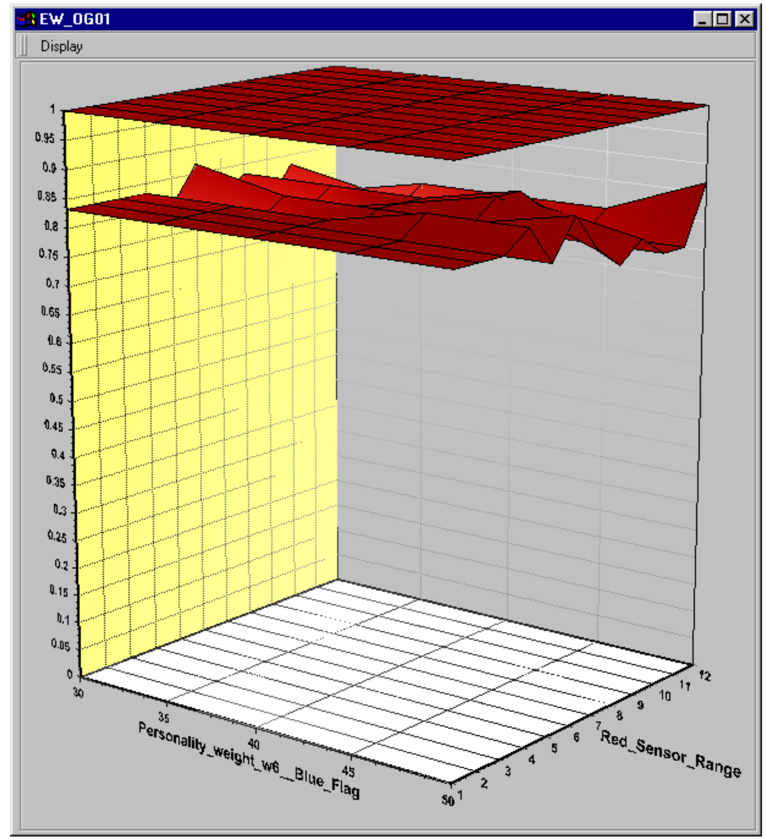
"Imagination is more important than knowledge"

Illustrative ISAAC Scenario

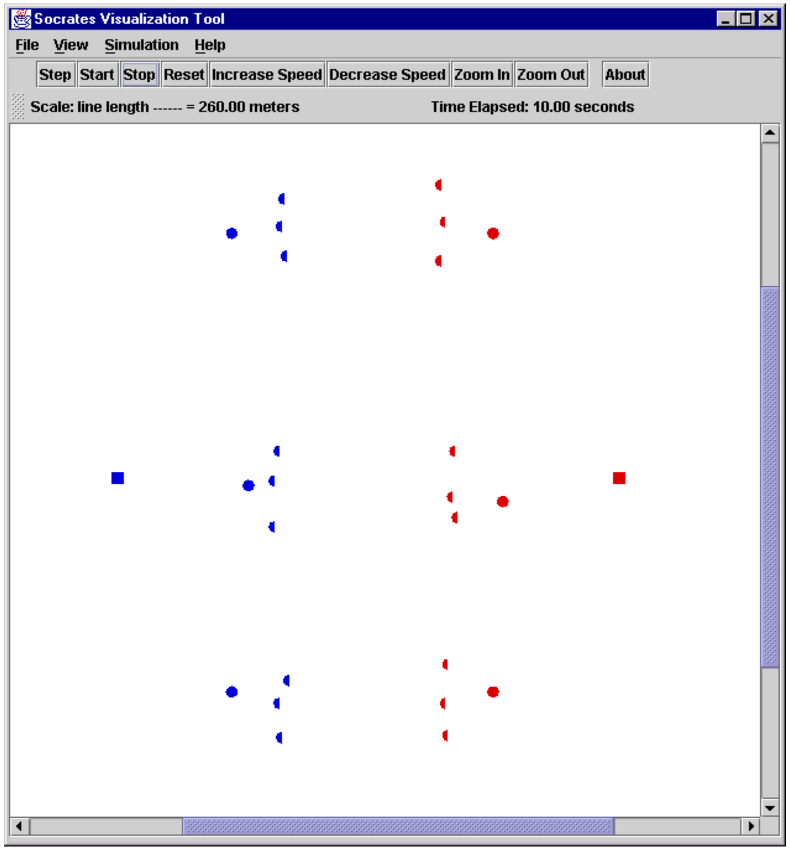


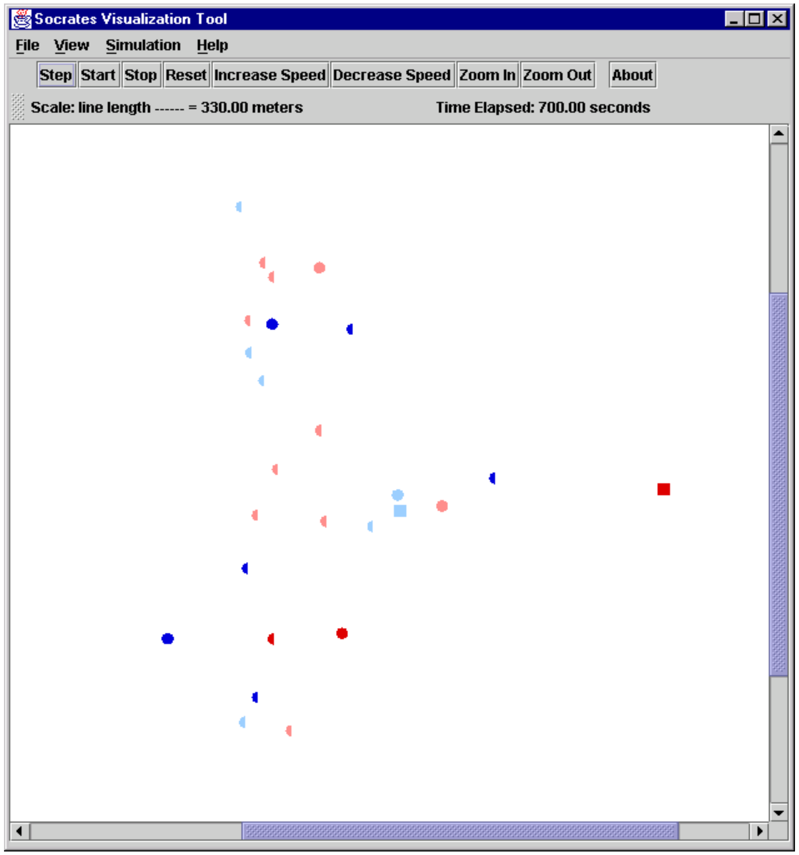
Illustrative Results: Enemy Within the Population



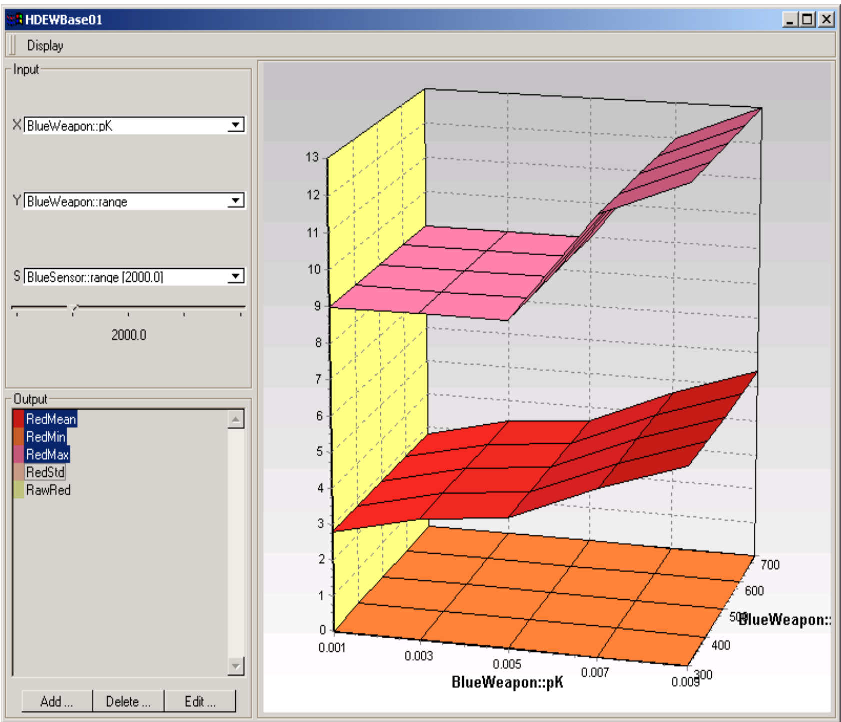


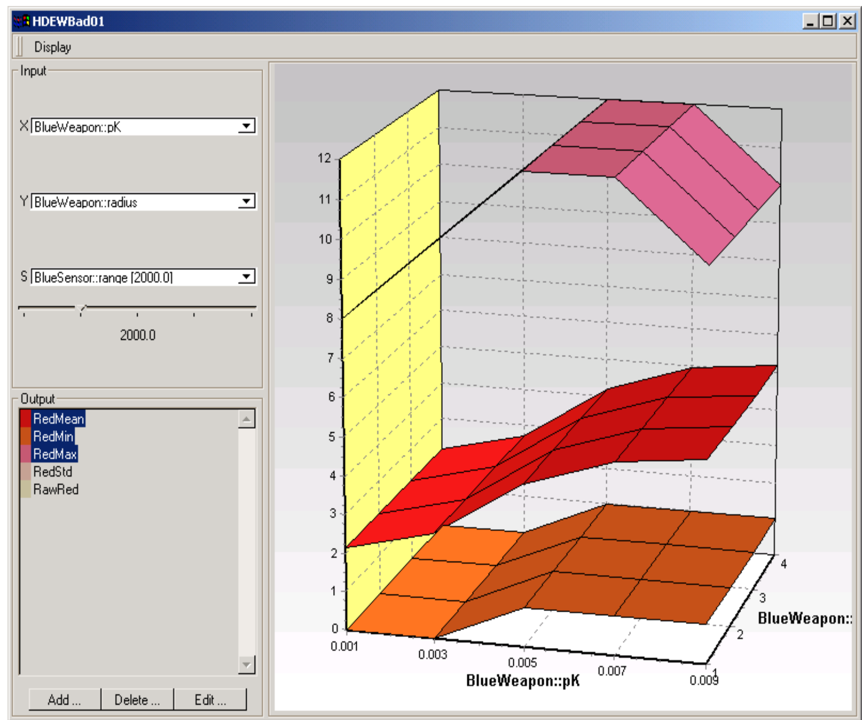
Illustrative Socrates Scenario





Illustrative Results:
Enemy within the Force





The interest in this issue: What does this mean?

- Tradition of homeland defense
- Preparation for unknown
- Combining techno- and human-centric approaches

A Dot is a Dot!

We are using abstract tools to encourage creative and lateral thinking which is needed in a new era of conducting military affairs

The Human-Centric Approach

We are learning from social science about two key issues

- **pattern recognition**
- **the process of asking the right questions**

Next Steps

Tests in the field of Network Centric Warfare based on the knowledge from the book Understanding Information Age Warfare

- **Information Domain - data gathering (more techno oriented)**
- **Cognitive Domain - thinking support (more human oriented)**
- **Physical Domain - more practical instrument designed for field use (techno/ human centric)**

Summary

- Continued collaboration
- Application of NATO CoBP
- Further research possibilities